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MARCONI INSTITUTE
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Technical Lesson 17

THE USE OF STORAGE BATTERIES ON SHIPBOARD

The purpose of the storage battery at sea is to provide a source of emergency power that may be used in place of the regular power equipment of the ship to operate the radio transmitting apparatus. There are two laws covering this emergency power supply, one an international law and the other a domestic law.

The International Radio Telegraphic regulations require an auxiliary source of power for the operation of the motor-generator of the regular radio equipment, or to operate a low-powered transmitter independently of the ship's generator, which is capable of functioning for at least 6 hours.

The United States Radio Act of August 13, 1912, stipulates that all vessels required to carry radio equipment shall have an emergency transmitting equipment that can be operated entirely independent of the current supply of the ship's generator. The emergency equipment must have a transmitting range of at least 100 miles during daylight hours and be able to function continuously for a period of four hours.

The auxiliary source of supply may be a small AC or DC generator operated by a gasoline or oil engine. In practically all cases, however, the operator will find a battery of storage cells as the auxiliary supply and for that reason he should be familiar with the operation and care necessary to maintain the battery at its highest efficiency. It must be remembered that the storage battery may be the only source of power available to operate the Radio transmitter if the regular power equipment should become inoperative.

The main emergency battery generally consists of sixty cells having a capacity sufficiently large to properly operate the radio transmitting apparatus in a manner to satisfy the laws governing such emergency apparatus. Two general types of storage cells are used in connection with emergency transmitters; namely, the lead plate, sulphuric acid cell, such as the "Chloride" and "Exide" types manufactured by the Electric Storage Battery Company, and the Edison, nickel iron alkali cell.

TYPES OF PLATES:- The plates most commonly used in the lead-acid storage cell are the pasted, or Fauré plates, and the Planté, or formed plates.

The Planté type of plate is made by taking pure lead, immersing it in an electrolyte and passing an electric current through the electrolyte and lead. This process, called forming, produces a coating of brown lead peroxide on the surface of the lead. It is this coating that constitutes the active material in this type of cell. Due to their excessive weight and large size, and the time required to form this type of plate, it is no longer used in the original form to any great extent.

In 1881 Fauré originated a method of making up the active material and pasting it on the lead plates. This was a great time saver, doing away with the tedious forming process of the raw lead plates. This method, however, had its disadvantages because the active material thus pasted on the flat surfaces of the lead plates had the distinct disadvantage of buckling and falling off as it was not an integral part of the plate. It was the skeleton framework or grid described in Lesson 16 that made the storage cell a commercial success. The modern storage cell uses a modification of one or both of these methods which will now be described.

THE POSITIVE PLATE OF THE EXIDE CHLORIDE TYPE PLATE:- Since the Planté method is used in making up this plate the openings and active material differ from the pasted type. The openings of this plate, which hold the active material, are not rectangular in shape but consist of $3/4$ inch holes.

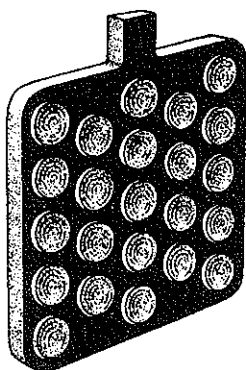


Figure 1

Pure soft lead which has first been cut from thin lead ribbon, and rolled into a spiral button, is forced by hydraulic pressure into these openings. This plate is shown in Figure 1. The pressure used in forcing in these buttons securely locks them in the openings and, as they heat by the charging or discharging of the cell, a further tightening results which has the two-fold purpose of better locking them in place and of making good electrical contact with the grid.

THE NEGATIVE PLATE OF THE CHLORIDE TYPE:- The negative plate is made up by the Fauré method (pasted plate); that is, the active material is made into a paste of finely divided porous lead and forced into square openings. This material, since it is not self-supporting, requires a finely perforated rubber shield which allows the acid to reach the plate but prevents the active material from falling away from the grid.

THE ELECTROLYTE:- The electrolyte of the Chloride cell is a 20% solution of sulphuric acid and does not employ chlorides, as the name might imply. The name "Chloride" is merely a trade name and designates that this particular type of battery is one using a combination of the Planté and Fauré types of plates, the positive being a formed type and the negative a pasted type.

THE IRONCLAD EXIDE CELL

The Exide "Ironclad" cell embodies the same fundamental principles as the type just discussed. The construction of this cell is somewhat different and is an improvement over the other types, in so far as the plate construction is concerned.

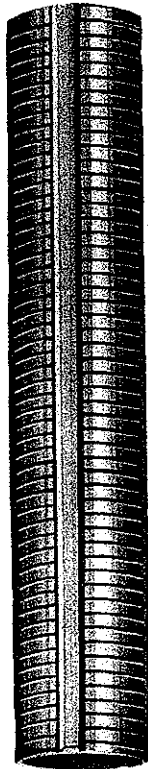


Figure 2

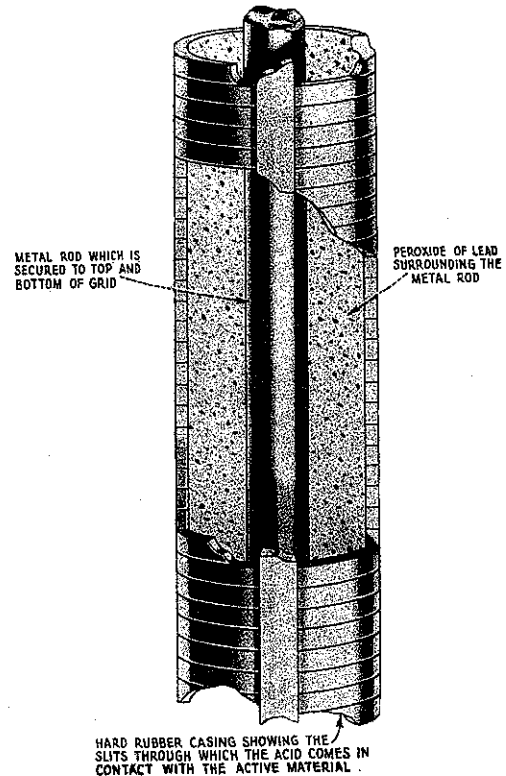


Figure 3

The negative plate of the Ironclad cell is very similar to the plate shown in Figure 3 of the previous lesson, with the exception of the top and bottom edges of the plate. A rubber casing is fitted to the top and bottom edges of the plate and vulcanized into place, the purpose being to eliminate the possibility of short circuits occurring from any material that might possibly bridge across from the positive plate.

The positive plate of the Ironclad cell is the improved feature of this cell. The grid of the plate is composed of a number of vertical lead alloy metal rods which are secured to the top and bottom of the grid. Around each metal rod is placed peroxide of lead in cylindrical form, this in turn is completely surrounded by a hard rubber casing which has a great number of small openings or slits, as shown in Figure 2, to allow the electrolyte to come in contact with the peroxide of lead, the active material. While these slits allow a free circulation of acid to the lead peroxide they are fine enough to prevent the active material from washing out.

In Figure 3 is shown a cutaway section of a tube of the positive plate with the metal rod, the peroxide of lead and the rubber casing clearly marked. Figure 4 shows the finished positive plate of the Ironclad storage cell.

The electrolyte of the Ironclad cell is a dilute solution of sulphuric acid, the specific gravity of which is designated by the manufacturer and which is usually 1.200 or 1.300.

TYPES AND RATINGS OF THE EXIDE CELL USED IN EMERGENCY EQUIPMENT

In the following table the smaller sizes of cells are used in connection with transmitting sets rated at 1/2 KW, the larger cells being employed where emergency lights aboard ship are to be supplied as well as the radio apparatus. In most installations where a 2 KW transmitter is used the 60-cell MVA-11 type Exide is employed.

Number of Cells	Type	Capacity in Ampere-Hours	
		At the 4-Hour Rate	At the 10-Hour Rate
60 cell	MVA-9	118 Ampere-Hours	137 Ampere-Hours
" "	" 11	147½ " "	171 " "
" "	" 13	177 " "	205 " "
" "	" 15	206½ " "	240 " "
" "	" 17	236 " "	274 " "

When severe conditions are to be imposed on the emergency storage battery equipment, such as excessive vibration, the Exide Ironclad battery is employed, assuring longer life under such conditions. The ratings of several sizes of this type of battery are given in the following table.

Number of Cells	Type	Capacity in Ampere-Hours	
		At the 4-Hour Rate	At the 10-Hour Rate
60 cell	MVA-9	122 Ampere-Hours	146 Ampere-Hours
" "	" 11	153 " "	183 " "
" "	" 13	184 " "	220 " "
" "	" 15	214 " "	256 " "
" "	" 17	245 " "	293 " "

On ships which are operated mostly in tropical waters, or on any ship when the battery has to be so located that it is continually subject to extremely high temperatures, the Exide 60-cell type "MVAL" battery is recommended. The same principles are embodied in this cell as in the "MVA" type. The detail of assembly, with but one exception, is the same and the same plates are used. The difference lies in the separation of the plates which are more widely spaced, allowing thicker separators to be used, and an electrolyte having a lower or weaker specific gravity. Both of these changes are desirable especially under high temperature operating conditions. This battery will give longer life than the standard marine radio battery type "MVA," the disadvantage being that, for the same capacity, it requires more space and weighs more.

When, for any reason, the 60-cell battery is not supplied, an emergency transmitter is employed. This is operated from a portable 12-cell, 24-volt battery having a smaller size cell. The 12-cell, type XC-15-1, is generally found in such installations. This type has a capacity of 100 ampere-hours at the 5-hour rate.

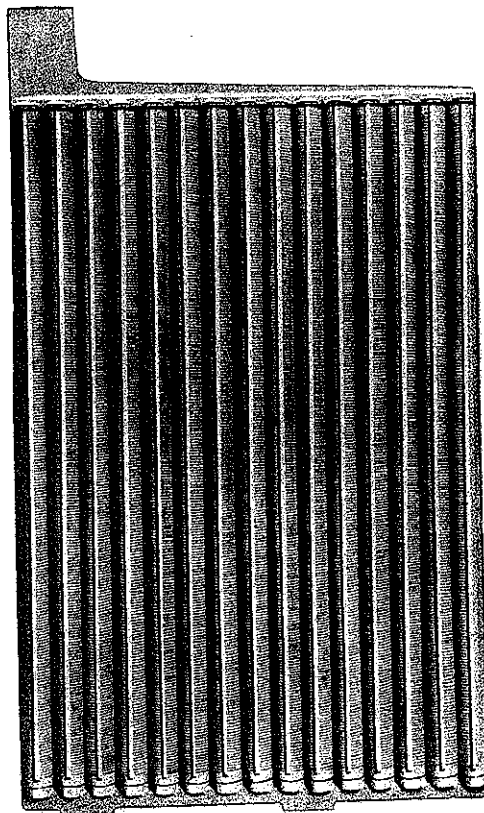


Figure 4

A storage battery is also employed to heat the filaments of the tubes in the receiving set. This storage battery is the portable type comprised of three cells giving a total of 6 volts. It is rated at 100 ampere-hours at the 10-hour rate.

Certain fundamental facts concerning the charge and discharge of storage cells and the circuits for their use will now be considered, followed by a complete description of the charging panel used in marine radio installation.

CHARGING STORAGE BATTERIES

This phase of the study was partially taken up in the previous lesson. In this lesson more detail is given, especially to the charging methods aboard ship. The charge is accomplished by connecting the positive terminal of the battery to the positive terminal of a source of direct current and the negative terminal to the negative side of the charging source. This is true because the chemical action must be reversed when the battery is to be charged, therefore the charging current must flow through the battery opposite in direction to that of discharge. The voltage of the charging source

must exceed the voltage of the battery, that is, the total voltage of all the cells of which the battery is composed must be less than the voltage available for charging purposes.

The polarity of the charging mains may be determined by one or all of the following methods:

1. By the use of a direct current voltmeter.
2. By chemical means.
3. By immersing the terminals of the charging source in a solution of salt water.

The terminals of the voltmeter are generally marked with polarity signs, +(positive) and - (negative). If the meter is correctly connected across the line a deflection of the needle enables the operator to read the E.M.F. in volts. If connected improperly no reading can be taken.

When two or more batteries are to be charged they are generally connected in series and, as the charging is usually from a 110-volt circuit, the total voltage of the battery when charged must not exceed 110 volts. The limiting resistance used to determine the charging rate may be either a fixed resistance, an adjustable rheostat, a lamp-bank, or a water rheostat. Illustrations of simple charging circuits employing these methods will be shown.

Figure 5 shows the method of charging by lamp-bank from a 110-volt source. Five 110-volt 16 candle-power carbon lamps are used as the means of controlling this charging current. Since one 110-volt 16-CP carbon lamp allows $1/2$ ampere to pass, five lamps connected as shown in the figure will charge the batteries at $2\ 1/2$ amperes. The group of lamps and the cells are connected in series with the charging line, and the current flowing through the cells will be determined by the number of lamps used. The charging current flows from the positive side of the line through the positive side of the switch, through the fuse, through the lamps, then through the cells and returns to the negative side of the line passing through the ammeter which measures the current passing through the cells. The lamp-bank may be connected in either the positive or negative side of the line but it must be always connected in series with the battery. The positive side of the line must always be connected to the positive terminal of the battery.

In using lamps as the resistance in a charging circuit it is recommended that the carbon filament lamp be used as this type has a greater current consumption for a certain amount of light than the tungsten filament type, and fewer lamps are required to obtain the necessary charging current.

It is always advisable to have an ammeter connected in the circuit to measure at all times the charging current. If an ammeter is not available the following rule, when employing either carbon or tungsten filament lamps, may be applied to obtain the approximate number of lamps to use when the line voltage, the charging rate in amperes, and the watt consumption of the lamps, are known.

For example, suppose you have 60 watt lamps, the charging rate is to be 6 amperes and the voltage is 110 volts. Multiply the charging rate times

the voltage and divide by the watt consumption per lamp. This is expressed as follows:

$$\frac{6 \times 110}{60} = \frac{660}{60} = 11$$

or eleven 60 watt lamps will be required.

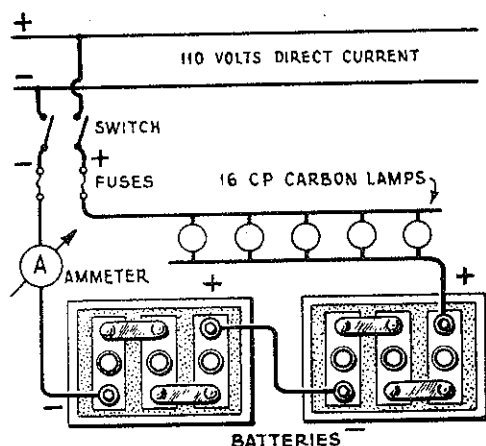


Figure 5

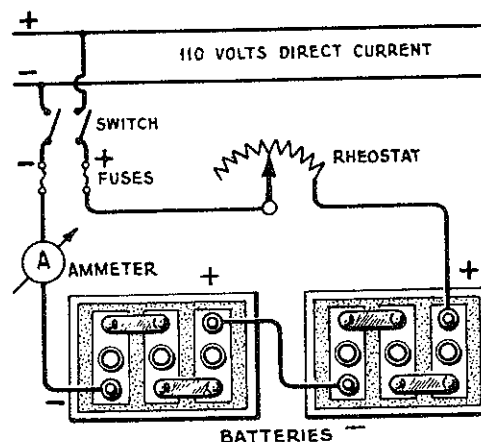


Figure 6

A charging circuit employing a rheostat is shown in Figure 6. This circuit may be employed where the voltage of the charging source is greater than the voltage required for the number of cells connected in series, and it may be adjusted to give any resistance within its range. When a resistor of this type is used the charging source must be slightly higher than the voltage of all the cells at the completion of the charge.

The voltage of the charging source MUST ALWAYS EXCEED the MAXIMUM voltage of the storage battery because the battery exerts a back pressure or counter electromotive force on the charging source and if the voltage of the charging source is LESS than that of the battery the latter will not be charged.

When charging a number of cells in series the charging resistance for a given battery may be determined by Ohm's Law.

Example: Assume that a given battery, when full charged, has a voltage of 30 volts, the normal charging rate as specified by the manufacturer is 6 amperes and the voltage of the charging source is 110 volts. The battery exerts a counter electromotive force of 30 volts on the charging source; the effective or net voltage, then, is $110 - 30 = 80$ volts.

For ordinary direct current circuits by Ohm's Law; $R = E/I$. But in our example, however, the value of the charging resistance is determined by;

$$R = \frac{E - e}{I}$$

Where E = the voltage of the charging source
 e = the fully charged voltage of the battery
 I = the normal charging current as specified by the manufacturer.

Substituting the known values in the formula and solving,

$$R = \frac{110 - 30}{6} = 13.3 \text{ ohms.}$$

Figure 7 illustrates a water rheostat, a form of resistance which may be used in an emergency when the regular means of resistance is not available. The current flows from the positive side of the line through the right hand side of the switch to the bottom metal plate, which may be any piece of metal easily obtained, through the salt water to the upper metal plate to the cells, and thus returns to the negative side of the line. Some means of adjusting the distance between the two metal plates is provided which will determine the current flow to the cells.

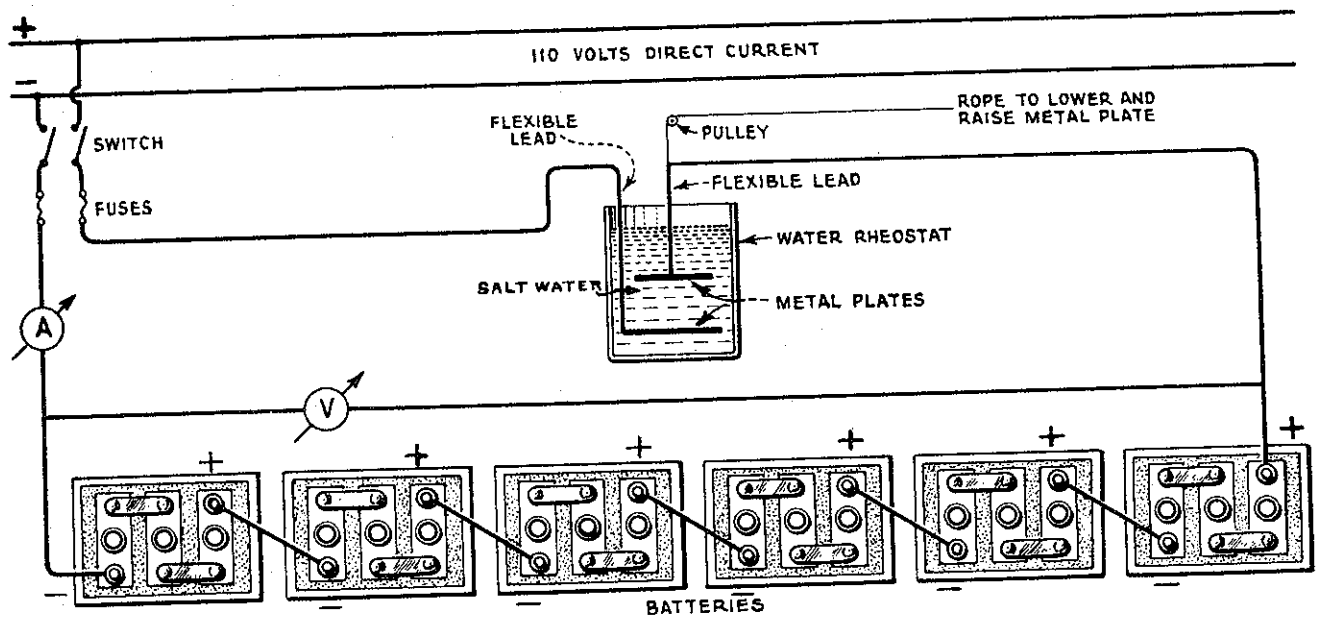


Figure 7

THE PANEL CHARGER

On shipboard the 60-cell emergency radio battery has a combined voltage too high to be charged from the ship's 110-volt line and because of this the battery is divided into two equal banks of 30 cells each for charging.

A switchboard panel especially designed for ship use and which is equipped with all the necessary apparatus for performing the various switching operations and for protecting the circuits is shown in Figure 8. The diagram showing the wiring back of this panel is shown in Figure 9 while Figure 10 is a diagram of the charging circuit connections and the meter circuit.

Instructions concerning the operation of this panel are explained in the following. The reversing switch is closed in the proper direction to give correct polarity. This will be indicated by the needle of the voltmeter which if the polarity is correct, will give a reading. If the needle does not swing over the scale but tends to move to the left where no reading can be observed, it is an indication that the polarity is reversed; therefore the reversing switch must be thrown in the reverse position.

The voltage of the battery is obtained by inserting the plug switch in the upper and lower right hand receptacles connecting the voltmeter circuit. As the voltmeter circuit is normally open a push button switch is provided on the switchboard for closing the circuit when it is desired to take voltmeter readings. The reason for this circuit being open is to prevent stray high frequency currents from flowing through the meter windings when the transmitter is in operation. The connections of this meter circuit are shown in Figure 10.

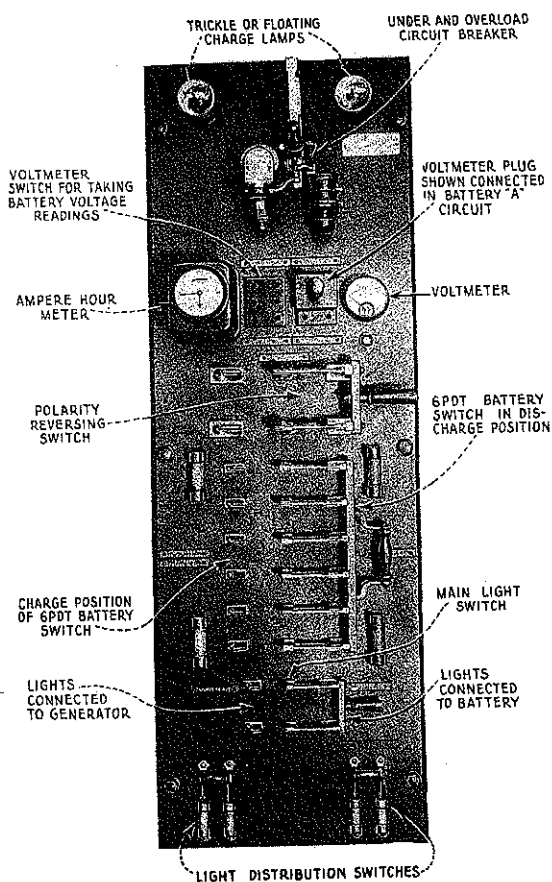


Figure 8

The next step is to open the 6-pole double-throw switch and close the circuit breaker, at the same time holding up the plunger of the low voltage release coil; now throw the 6-pole double-throw switch to the left, thus connecting the two battery banks to the charging source through the charging resistors. These resistance units are plainly marked and shown in both Figures 9 and 10.

The ampere-hour meter is our next consideration. Over the face of this instrument will be seen two indicating hands, one black and the other red in color. The red hand should now be moved until it points to the number corresponding to the ampere-hours as specified by the manufacturer for the size of the battery to be charged. The black hand indicates the state of discharge of the batteries at all times. With the 6-pole double-throw switch to the left the batteries are on charge, and the amount of charge

will be indicated by the black hand which will move toward zero and, when it reaches zero, the battery is charged. The black hand, on reaching the zero position, makes an electrical contact which short circuits the holding-magnet windings of the circuit breaker through a small resistance and the circuit breaker opens, thus automatically opening the charging circuit.

At stated periods, generally about once each month, it is best to give the batteries an over-charge. To do this the cover of the ampere-hour meter is removed and the black hand moved back half-way to the red hand; the cover is then replaced and the battery placed on charge. At the completion of the over-charge the charging current is automatically cut off by the black hand making contact at the zero position and thereby opening the circuit breaker. It is important that the ampere-hour meter be given the proper attention which will insure it being maintained in good operating condition. When possible the meter should be overhauled and recalibrated once every twelve or eighteen months.

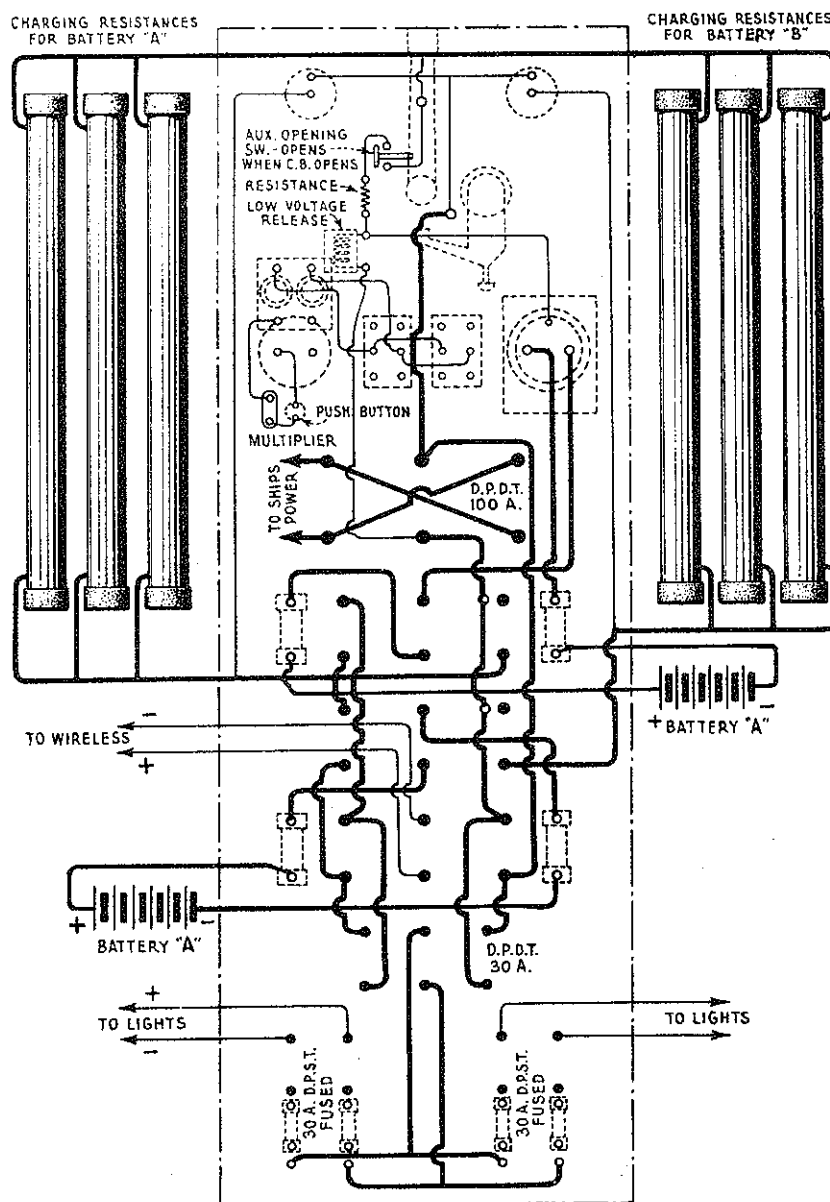


Figure 9

THE CIRCUIT BREAKER

The circuit breaker is equipped with a low-voltage release device which functions when the voltage from the ship's generator drops below the proper potential. If for any reason voltage from the ship's mains drops below the voltage of the batteries the no-load or low voltage release will operate by opening the circuit, thereby preventing the battery from discharging back into the ship's mains. As long as the voltage of the ship's generator is high enough to force sufficient current through the magnet which holds the

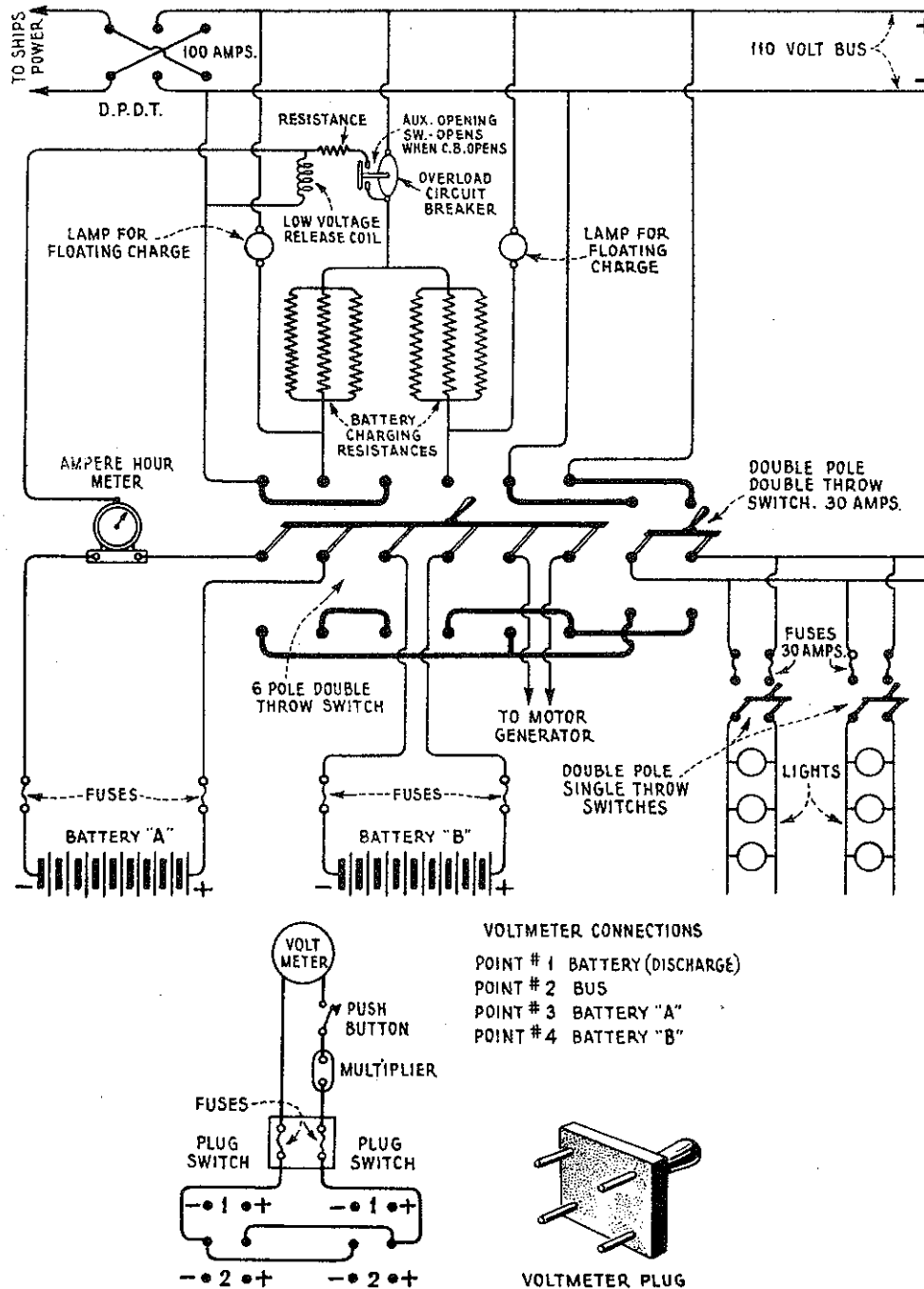


Figure 10

low-voltage plunger up in place the circuit will remain closed. When the voltage drops or fails the magnetic field developed in the magnet holding the plunger ceases and the plunger, which is metal, drops and trips a lock which holds the circuit breaker in place.

If the ship's generator fails the batteries may be used to supply the current for the ship's lights.

THE FLOATING OR TRICKLE CHARGE

When the 6-pole double-throw switch (abbreviated 6-PDT) is closed to the left, with the circuit breaker open, the regular charging resistor circuit will be open. The battery will, however, receive a trickle charge through the two lamps which are shown mounted at the upper left and right hand corners of the charging panel, Figure 8. This is the normal position of the switches on the panel when the battery is fully charged and the ship's power is being used to supply power for the transmitter. In this way the battery is always maintained at full charge ready to be used in case of an emergency.

When the battery is on trickle or floating charge the lights cannot be operated from it. It therefore becomes necessary to close the lower DPDT switch to the left. The distribution switches for the lights, shown on the extreme lower part of the panel, may be operated as desired.

When the circuit breaker is open and the 6-PDT switch closed to the right, which is the discharging position, the lights may be operated from either the ship's line or from the battery by closing the lower DPDT switch, marked "Lights," to the right or left, depending upon the source of power to be drawn from. When the ship's generator plant is for any reason not operating, the radio switch on the ship's switchboard and all the switches on the battery panel switchboard must be opened. Under such conditions never use the battery for supplying the light circuits except in case of emergency.

EFFICIENCY OF BATTERIES

We might assume that by sending a predetermined amount of current into a battery the same amount can be taken from it. This, however, is not practical which you may prove by the following formula:

$$\text{Efficiency} = \frac{\text{The watt hours output}}{\text{The watt hours input to recharge}}$$

For this reason the battery is given an over-charge periodically.

BATTERY CLEANLINESS:- Dampness and accumulation of dirt about the tops of the battery will lower its efficiency because they permit the accumulated charge to slowly leak away and produce corrosion about the battery terminals by holding small quantities of the battery solution carried out of the ventilating holes by the gas. The terminals should be scraped clean and thoroughly greased with clean white vaseline to prevent corrosion.

ELECTROLYTE:- The electrolyte should always be kept one-half inch above the tops of the plates. When evaporation has reduced the solution add distilled

water only before charging. As the acid does not evaporate new acid should never be added unless the battery solution has been spilled out.

STATE OF CHARGE:- The battery should be kept in a state of full charge at all times and the trickle or floating charge should be in operation at all times except when the battery is being charged or discharged. The trickle charge lamps will burn a dull red when the trickle charge is operating. Should either of these lamps burn out replace immediately with another of the same rating. The gas arising from the battery is explosive and all open flames must be kept away from the battery at all times.

The polarity of the generator should be checked often to guard against the battery being accidentally discharged through the reversal of the generator. This may be accomplished by taking voltmeter readings frequently by means of the voltmeter plugs on the switchboard.

The battery should be frequently inspected for leaky jars and if a leaky jar is found it must be immediately replaced and the old one repaired or discarded entirely. Carefully watch the terminals; see that all connections to the terminals are clean and tight thus assuring good electrical contact.

Prevent impurities from entering the cell as this may cause local action and, in time, ruin the plates of the cell.

TESTING FOR CONDITION OF CHARGE:- The hydrometer is the only means by which the state of charge should be determined as this gives the measure of the amount of acid which has gone to form sulphate on the plates.

The voltmeter tells little or nothing as to the state of charge of the battery when measured on open circuit. When the voltmeter is employed to ascertain the state of charge it must be done when the battery is either in the process of charging or discharging at the normal rate.

The fully charged storage cell should read from 2.5 to 2.6 volts when on charge and approximately 2.1 volts when on discharge. The voltage should never be allowed to drop below 1.8 volts.

The specific gravity of the fully charged battery should measure from 1.280 to 1.300 and, when fully discharged, 1.150.

The temperature of the electrolyte should not be higher than 105 degrees (F) when the battery is on charge.

COMMON TROUBLES

The storage battery may become inactive from one of two causes,—either due to a lack of charge or trouble internally. If it is lack of charge a hydrometer reading taken of all the cells should show a low, but uniform, specific gravity measurement for each cell,—the remedy then is to place on charge. If one or two cells show a marked difference in specific gravity reading, the cause is probably internal trouble and the battery should be overhauled.

BUCKLING OF PLATES:- When a storage battery is subject to long excessive charging or discharging the elements heat beyond the safe limit and, if this practice is continually repeated, the plates buckle causing the active material to drop out of the grids, thus ruining the cell.

The cause of the excessive charge may be due to faulty charging apparatus or it may be carelessness on the part of the person who has charge of the battery; in either case the remedy is obvious.

SULPHATION:- Sulphation, as explained, forms on the plates on discharge and accumulates rapidly unless the battery is kept in a well charged state. When the plates become exposed to the air sulphation rapidly sets in forming a hard crystalized coating over the plates. This greatly increases the internal resistance of the cell and requires a long over-charge at a low rate to break up this condition. Regular charging and maintaining a proper height of electrolyte will, to a large extent, prevent sulphation.

PLACING BATTERIES OUT OF SERVICE:- Should it become necessary to place the batteries out of commission for several months they should be given a complete inspection, the terminals thoroughly cleaned, electrolyte properly covering the plates, and then fully charged. Before placing them again in active service a thorough charge should be applied until the specific gravity and voltage remain constant for a period of five hours.

DRY STORAGE:- The same instructions apply to this procedure as above with the exception that the electrolyte, after the cells have been fully charged, is removed. The plates are washed with clean cold water and the battery then stored in a dry cool place. Care should be taken to see that the positive and negative groups do not come in contact with each other while this is being done. The separators are removed and thrown away and new ones used when the battery is again put in commission.

THE EDISON STORAGE BATTERY

The Edison storage battery employs a principle which differs radically from that of all other storage batteries. It is the only storage battery having iron or steel in its construction; no lead whatever being employed. The grids and the jars are constructed of steel.

The electrolyte of the Edison cell is an alkaline solution and it has none of the disadvantages of the acid solution; it does not give off noxious fumes during the charging process and, if accidentally spilled, will not injure metal fastenings of the hull if it runs into the bilge. The solution is, in fact, a preserver of steel and nickel and therefore prevents many of the troubles arising in storage battery practice.

The chemical composition of the electrolyte is a 21% solution of caustic potash to which is added a small amount of lithium hydrate. The density or specific gravity of this solution, which does not change, is from 1.200 to 1.230. During charge the water of the solution is driven off as gas as in the lead acid cell and it is necessary to add distilled water when the electrolyte drops below the level of the top of the plates. When the Edison cell is first charged, or when the battery is given a long over-charge, considerable water evaporates.

The active material of the positive plate is nickel hydrate and pure nickel flake, the latter to increase conductivity. The negative plate employs iron oxide to which is added a small quantity of mercury oxide to increase the conductivity.

The positive plate is made up of a number of perforated, spirally wound, steel tubes into which are packed, under heavy pressure, alternate layers of nickel hydrate and pure nickel flake. The flake nickel, which is placed between each layer of nickel hydrate, is about the thickness of tissue paper and about 1/16 inch square. Figure 11 shows a magnified section of a positive tube in which the nickel hydrate appears as the light layers and the pure nickel flake as dark horizontal lines. When the tube has been completely loaded it is strengthened mechanically by encircling it with seamless steel rings as shown in Figure 12.

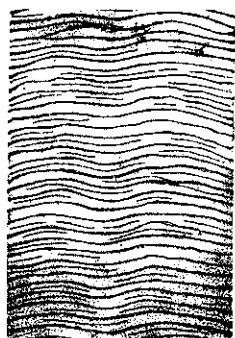


Figure 11



Figure 12

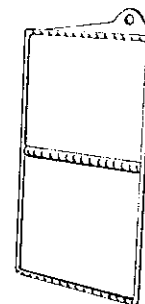


Figure 13

The grid is made of steel into which the tubes just described are forced, giving a mechanically strong plate which is capable of withstanding continual shocks and vibration. The grid is shown in Figure 13 and the completed positive plate at A, Figure 14.

The negative plate is made up of a number of flat perforated steel containers or pockets into which is packed iron oxide with a small amount of mercury oxide. After these pockets, shown in Figure 15, are packed and closed they are placed in the openings of the negative grid, shown in Figure 16, and forced into permanent place and contact by hydraulic pressure. The completed negative plate is shown at B, Figure 14.

The positive and negative plates are now mounted on steel rods which are integral with the tapered steel poles projecting through the top of the cell for external connection. After the positive and negative groups have been formed they are interleaved as shown in Figure 17.

The positive and negative groups are insulated from each other by a suitable rubber insulation which prevents them from making electrical contact. Figure 18 shows the two groups assembled and ready to be placed in the steel container.

The container is made of a high grade sheet steel heavily nickel plated, as are all other parts of the cell. All seams and joints necessary in its

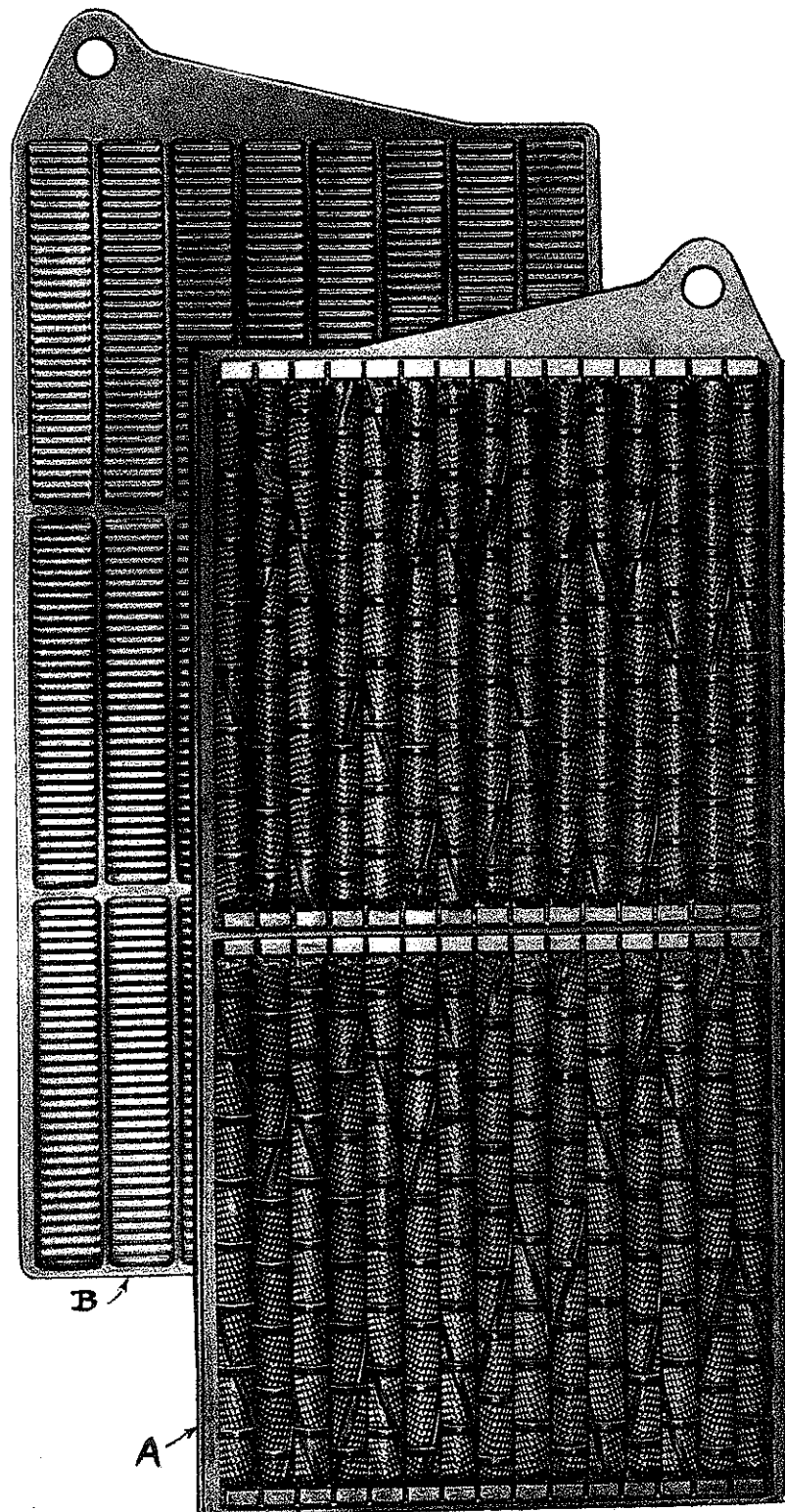


Figure 14

construction are sealed by means of welding. The container is tightly sealed except for the opening in the top which is provided for the escape of gases that are given off during the process of charge, and for the addition of water and electrolyte. The opening provided with a spring filler cap which contains a gas valve, while the openings through which the tapered terminals pass are sealed with soft rubber gaskets. Figure 19 shows the construction of the top of the container.

A cutaway view of the completed Edison case is shown in Figure 20 in which each part is plainly marked.



Figure 15



Figure 16

THE CHEMICAL ACTION OF THE EDISON CELL:- The chemical process taking place in the Edison cell is as follows:

The first charging of the Edison cell reduces the iron oxide to a metallic iron, while converting the nickel hydrate to a very high oxide, black in color.

On discharge, the metallic iron goes back to iron oxide and the high nickel oxide goes to a lower oxide, but not to its original form. On every cycle thereafter the negative charges to metallic iron and discharges to iron oxide while the positive plate charges to a high nickel oxide.

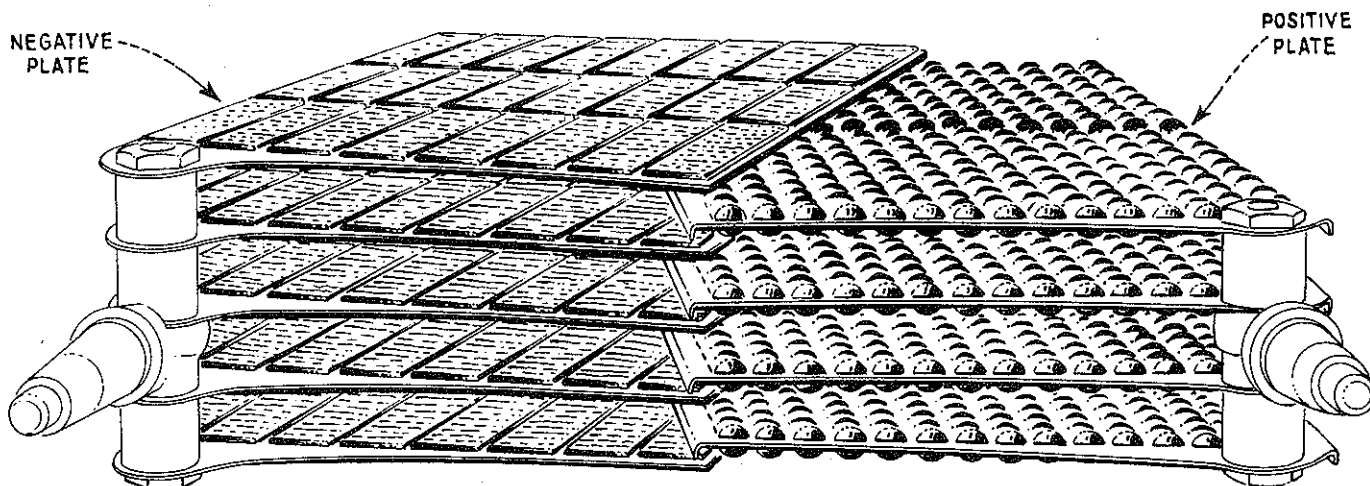


Figure 17

Current passing in the direction of charge or discharge decomposes the potassium hydrate of the electrolyte, and the oxidation and reduction of the electrode are brought about by the action of its elements.

An amount of potassium hydrate equal to that decomposed is always reformed at one of the electrodes by a secondary chemical reaction, in consequence there is none of it lost and its density remains constant.

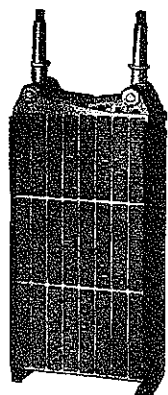


Figure 18

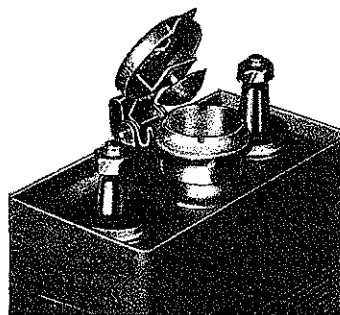


Figure 19

The final result of charging is, therefore, the transference of oxygen from the iron to the nickel electrodes and that of discharging is the transference back again.

A hydrometer reading of this cell is not required as the specific gravity of the electrolyte does not change with the state of charge or discharge and consequently the only direct method of making a measurement of the state of charge is with an ampere-hour meter or by the correct use of a voltmeter.

CHARACTERISTICS OF THE EDISON CELL:- The voltage of the Edison cell is only 1.2 volts on normal discharge. The disadvantage of this low voltage is offset by the ease with which the battery is cared for. It may be left standing for long periods without injury providing the electrolyte is at the proper level above the plates. It will suffer no damage by being subjected to extreme cold. It may be charged or discharged at rapid rates providing the temperature of the electrolyte does not exceed 115 degrees (F). Its maintenance cost is low and its great strength enables it to be subjected to rough treatment without injury.

The charging voltage of this cell is from 1.5 volts to 1.8 volts per cell depending upon the type. Full instruction concerning the charging rate accompanies each cell. The cell should be charged when the voltage has fallen to 0.9 volts.

If the battery is accidentally given a charge in the wrong direction no permanent injury will result, however, the battery should at once be given a long charge in the right direction to restore the cells to proper condition.

When on charge a free gassing of the cells is an indication of a healthy condition. Frothing, however, is a sure indication that something is wrong; foreign substances have gotten into the cell, or the electrolyte

is too high and, if this condition continues for any length of time, the electrolyte should be emptied out and a new solution added.

The different types of Edison batteries are designated by letters and numerals. Cells bearing the same letter, as A-4 and A-12, or G-6 and G-9, are composed of the same kind of plates and differ only in the number of plates.

The numeral indicates the number of POSITIVE plates. For example, the cell designated as A-4 has four positive plates, and A-12 has twelve positive plates. In all types of Edison cells the number of negative plates exceeds the positive by one.

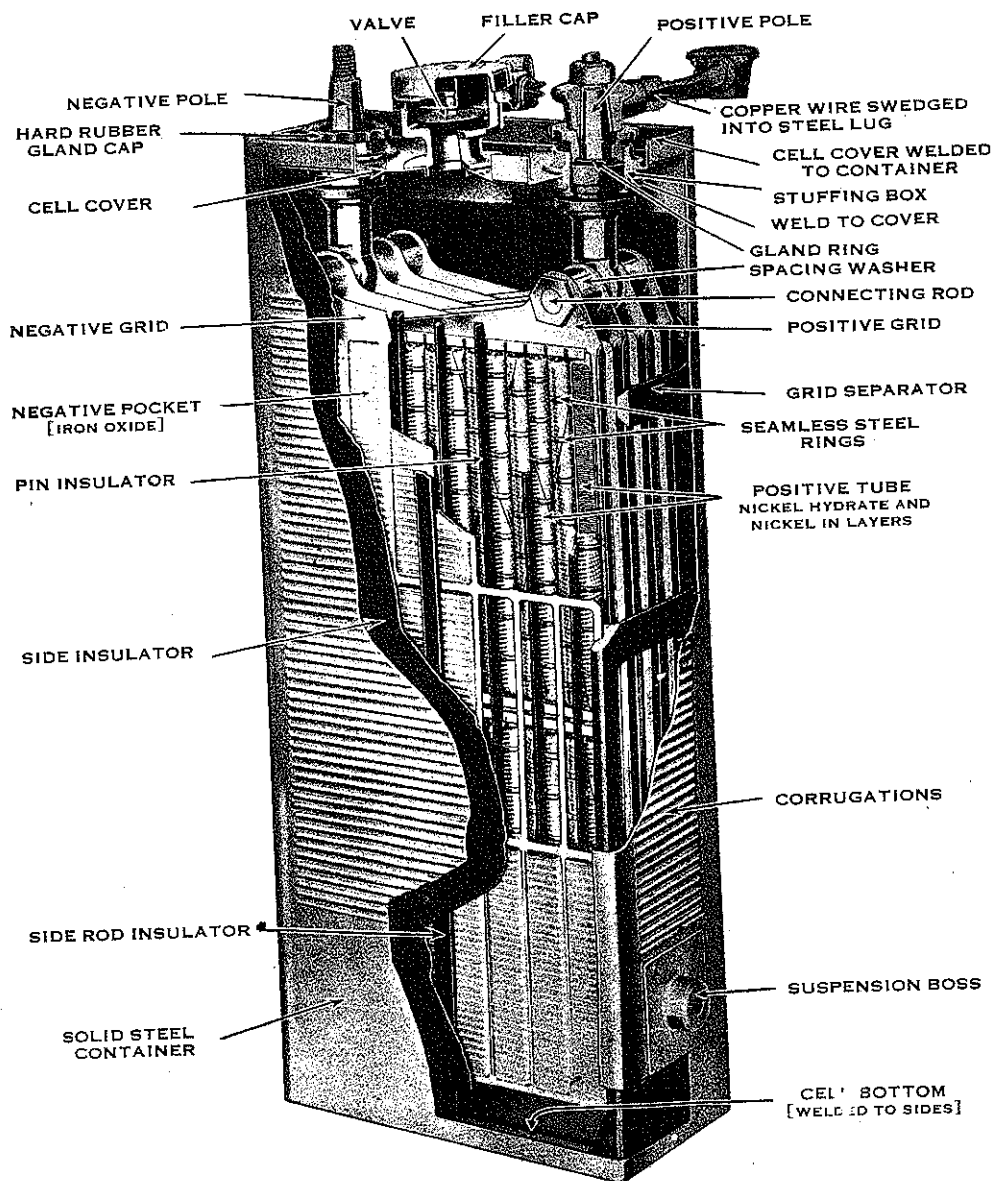


Figure 20

EXAMINATION - LESSON 17

1. How does the Ironclad Exide cell differ from the MVA type described in the previous lesson?
2. How does the Edison cell differ from the Exide?
3. What type of lead acid cell is best adapted for use when subjected to radical climatic changes?
4. Explain fully how you would determine the polarity of the charging source.
5. How is the state of charge of the Edison cell determined?
6. Why are storage batteries used on shipboard?
7. What are some of the advantages of the Edison cell?
8. (a) What is the maximum voltage of the Exide storage cell?
(b) The Edison?
9. What electrolyte is used in the Edison cell?
10. What is the maximum allowable temperature of the electrolyte of a lead acid cell when on charge?